MODELING AND SIMULATION OF THE ORTHOGONAL CUT BY USING THE LAW OF DAMAGE

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Abstract

The principal objective of our work is to simulate the orthogonal cutting process a computer code by the finite element method which is ABAQUS by its explicit integration diagram and by quoting the method of the adaptive grid (ALE) and the law of Johnson- Cook behavior established in ABAQUS. This study is carried out for a steel of the 42CD4 type and a tool of which the angle of cut is 6°. The tool has a presumedly rigid.

Keywords: Orthogonal cutting, Finite Element Method, Adaptatif Mesh, damage, Johnson-Cook low

Introduction

In working, the contact and friction between the parts and the tools play a big role. Indeed, the final geometry of the formed product depends on friction. The forces and the concerned couples increase with friction, [1]. Modeling by finite elements of working of the parts, having nonlinearities geometrically and numerically, requires a mending of meshes.

In this work, one presents the digital simulation of the formation of the chip out of orthogonal cut which is carried out on software ABAQUS 6.5 [2].

Law of behavior and damage of material machines

The law chosen to represent the physique of the process is that of Johnson-Cook [3], usually used in the literature to simulate this type of operation.

$$\sigma\left(\varepsilon_{eq},\dot{\varepsilon}_{eq},T\right) = \underbrace{\left(A + B\left(\varepsilon_{eq}^{p}\right)^{n}\right)}_{Term\ of\ work\ hardening} \underbrace{\left(1 + C ln\left(\frac{\dot{\varepsilon}_{eq}^{p}}{\dot{\varepsilon}_{0}}\right)\right)}_{Dynamic\ \ term\ :f_d} \underbrace{\left(1 - \left(\frac{T - T_t}{T_f - T_t}\right)^{m}\right)}_{Term\ of\ softening\ :f_a} \qquad (1)$$

This law of flow breaks up into three terms: a term of work hardening, a dynamic term and a term of softening.

The term relating to work hardening corresponds to the yield stress at speed of constant deformation $\left(\dot{\varepsilon}_{eq}^{p} = \dot{\varepsilon}_{0}\right)$and to the constant temperature$(T = T_t)$.

A is the yield stress to null plastic deformation, *B* and *n* are respectively the linear and nonlinear parameters of work hardening.

The second term is a multiplicative factor noted $f_d$characterizing the dynamic hardening of material. This term thus depends on the speed of equivalent plastic deformation. *C* is the coefficient of sensitivity at the speed of deformation and $\dot{\varepsilon}_0$is a speed of deformation of reference.

The third term of the law is a factor noted $f_a$corresponding to the thermal phenomenon of softening. In lower part of the temperature of $T_t$transition, the effect of the temperature on the law of flow is neglected. For temperatures ranging between $T_t$and the melting pointT_f, the yield stress decreases with the temperature to become null for $\left(T = T_f\right)$.

Beyond the melting point, the yield stress is practically null. T_t is the temperature of transition from which one has a thermal mechanism of softening, and *m* being the thermal exhibitor of softening. Table 1 respectively gives the material characteristics and the coefficients of the law of Johnson - Cook of the material 42CD4, [4]:

Table 1 Material characteristics and coefficients of the law of behavior of johnson-cook.

Material characteristics		**Parameters of Johnson- Cook**	
ρ (Kg/m^3)	7800	A(Mpa)	595
E (Mpa)	210000	B(Mpa)	580
ν	0.3	n	0.133
C_v (J/Kg.K)	379	C	0.023
k (W/ (mK))	46	m	1.03
		$\dot{\varepsilon}_0$(s^{-1})	0.001
		T_{amb}(°K)	293
		T_{fus}(°K)	1793

Boundary conditions and loading

The part is modelled in plane deformations and it is fixed by an embedding at its base. Its length is of31.4 mm (diameter Ø10 mm) and its width is of 15 mm, (fig. 1). The tool is modelled by a rigid body of angle of cut 6°.

The clearance angle is worth 5° and the ray of the nozzle is worth 0.1mm. It is animated of a translatory movement at a cutting speed Vc=15 m/s. The initial temperature of the part and the tool is of 20°C (293°K). Depth of cut ap=0,2mm. The contact between the tool and the machined part is considered with friction this last is estimated at μ=0.2.

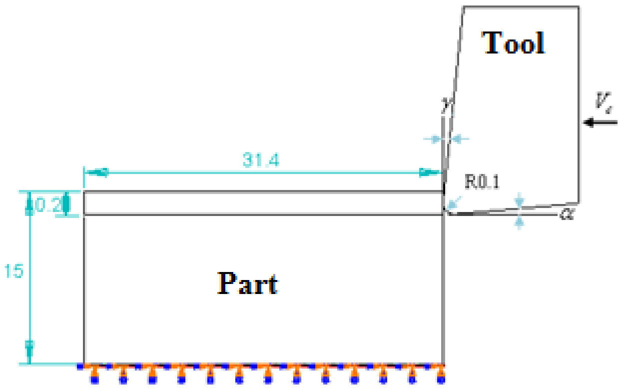

Fig.1. Machining out of orthogonal cut

Simulation of the orthogonal cut

One used for this simulation a rigid tool with the angle of cut 6°. On the fig. 2, one observes that the grid was refined dice the first contact between the tool and the part thanks to function ADAPTIVE MESH.

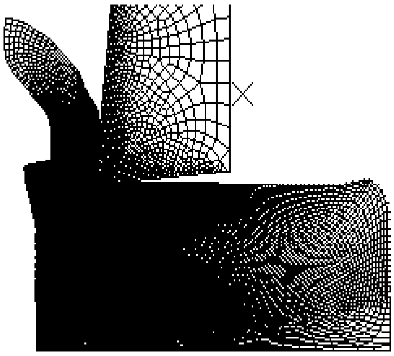

Fig.2. Morphology of the chip for the angle of cut γ=6°.

The fact of taking a great angle (more cutting tool) generates a facility in the formation of the chips. It is noted finally that the chip formed by this method is a continuous chip.

Distributions of the equivalent constraint of Von Mises (fig. 3) and the field of temperature (fig. 4) are presented in our simulation.

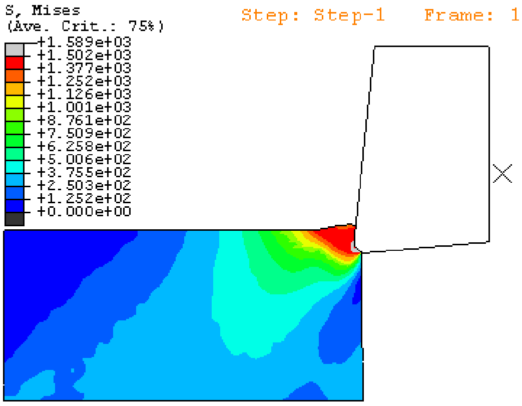

Fig.3. Equivalent constraint of Von Mises, γ=6°.

One notices the appearance of the zone of separation of metal at a peak of the tool (in gray). In this area, the tool exerts a compressive force on the material which is driven back and separates in two parts: the chip and the machined part. One notices also the appearance of the primary education zone of shearing (red) and secondary (out of orange).

The temperature in the zone of separation tool part is of 151.7°C (fig. 4), then it passes from 393.7°C on the point of the tool (frame 8) to 462.7°C in frame 35 and in all the courses of the tool and finally the temperature releases itself through the chip.

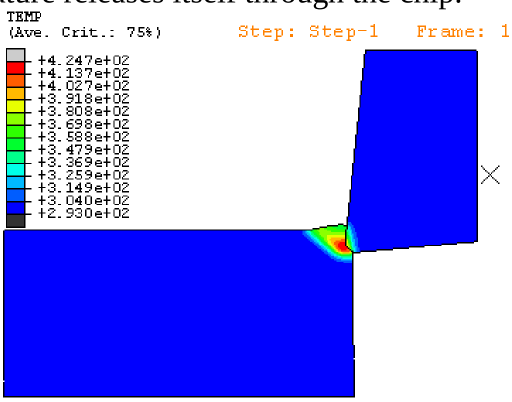

Fig.4. Distribution of the temperatures, γ=6°.

The heat generated with the interface is due to plastic work in the part and which is diffused in the tool (fig.5).

One notices an increase in the plastic deformation equivalent to traverses tool in the primary zone of shearing, where the constraints are most important.

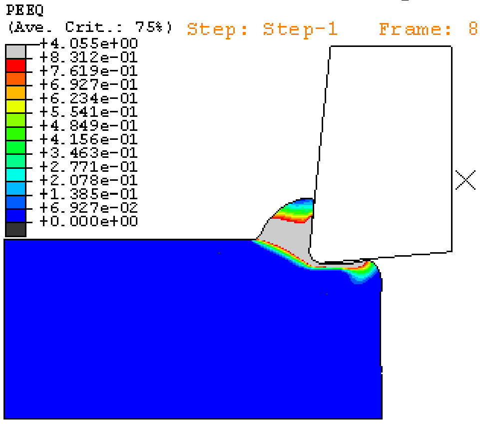

Fig.5. Equivalent plastic deformation, γ=6°.

Conclusion

Our main aim was the study of the phenomenon of removal of the matter and more exactly in the case of the orthogonal cut, by using the finite element method.

- One studied the formation of the chips and their morphologies.
- The chips formed by the method of the adaptive grid are continuous chips.
- One identified the problem of distortion of the grid and its remedy is the adaptive grid.

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